CLAIMS

1. A method for identifying and measuring electrocardiographic alternans from at least one electrocardiographic (ECG) signal representative of the electric activity of a heart of a patient, the method comprising the steps of:

obtaining the ECG signal over a predetermined number of cardiac cycles of the patient's heart;

dividing the ECG signal into its individual cardiac cycles, each cardiac cycle having a depolarization portion and a repolarization portion;

measuring the amplitude of a plurality of repolarization segments contained in the repolarization portion of each cardiac cycle, the amplitude of each repolarization segment being measured from a repolarization reference baseline defined by a first base segment occurring immediately prior to the repolarization portion of the present cardiac cycle and a second base segment occurring immediately prior to the depolarization portion of the subsequent cardiac cycle; and

digitally processing the amplitude measurements for the repolarization segments to determine the presence of alternans in the physiologic signals.

2. The method of claim 1 wherein the step of obtaining the ECG signal includes:

obtaining a twelve lead ECG signal over the predetermined number of cardiac cycles; and

reducing the twelve lead ECG signal to an orthogonal 3-dimensional lead set.

3. The method of claim 2 wherein the twelve lead ECG signal is reduced to the 3-dimensional set by selecting the three leads of the twelve lead ECG signal that have the largest mean-square amplitude.

4. The method of claim 1 further comprising the step of measuring the amplitude of a plurality of depolarization segments contained in the depolarization portion of each cardiac cycle, the amplitude of each depolarization segment being measured from a second reference baseline defined by a third base segment occurring immediately prior to the depolarization portion of the present cardiac cycle and the

second base segment occurring immediately prior to the depolarization portion of the subsequent cardiac cycle.

5. The method of claim 4 wherein the ECG signal includes three ECG signals taken from three leads and the amplitude of the repolarization portion of each cardiac cycle is measured at four repolarization segments for each of the three leads, such that twelve amplitude measurements are taken over the repolarization segment of each cardiac cycle.

6. The method of claim 5 wherein the digital processing of the twelve amplitude measurements for the repolarization segments includes:

filtering the amplitude measurements to remove the low frequency portion of each measurement;

transforming the twelve amplitude measurements into eigenvariables by using singular value decomposition; and

calculating a spectral density from each of the eigenvariables, wherein the spectral density for each of the eigenvariables are used to locate alternans.

7. The method of claim 5 wherein the ECG signal includes three ECG signals taken from three leads and the amplitude of the depolarization of each cardiac cycle is measured at four depolarization segments for each of the three leads, such that twelve amplitude measurements are taken over the depolarization segment of each cardiac cycle.

8. The method of claim 7 wherein the digital processing of the twelve amplitude measurements of the depolarization portion of each cardiac cycle includes:

filtering the amplitude measurements to remove the low frequency portion of each amplitude measurement;

transforming the twelve amplitude measurements of the depolarization portion into eigenvariables by using singular value decomposition;

calculating a spectral density from each of the eigenvariables; and

determining the respiration frequency from the maximum spectral density of the first eigenvariable calculated from the depolarization portion of the cardiac cycle.

9. A method for measuring electrocardiographic alternans and the respiratory frequency from a plurality of electrocardiographic (ECG) signals representative of the electric activity of a heart of a patient, the method comprising the steps of:

obtaining the ECG signals over a predetermined number of cardiac cycles of the patient's heart from three leads;

dividing each ECG signal into individual cardiac cycles, each cardiac cycle having a depolarization portion and a repolarization portion;

measuring the amplitude of a plurality of depolarization segments of the depolarization portion of each cardiac cycle from each of the three leads;

measuring the amplitude of a plurality of repolarization segments of the repolarization portion of each cardiac cycle from each of the three leads;

transforming the plurality of amplitude measurements taken during the depolarization portion of each cardiac cycle into eigenvariables using singular value decomposition;

calculating a spectral density from each of the eigenvariables; and

determining a respiration frequency from the maximum spectral density of the first eigenvariable from the depolarization portion of the cardiac cycle.

10. The method of claim 9 wherein the amplitude of the plurality of repolarization segments are measured from a reference baseline defined by a first base segment occurring immediately prior to the repolarization portion of the present cardiac cycle and a second base segment occurring immediately prior to the depolarization portion of the subsequent cardiac cycle.

11. The method of claim 10 wherein the amplitude of the plurality of depolarization segments are measured from a second reference baseline defined by a third base segment occurring immediately prior to the depolarization portion of the present cardiac cycle and the second base segment occurring immediately prior to the depolarization portion of the subsequent cardiac cycle.

12. The method of claim 11 wherein the amplitude of each ECG signal

is measured over four depolarization segments and four repolarization segments of each cardiac cycle.

13. The method of claim 12 further comprising the steps of:

filtering the amplitude measurements taken for each of the repolarization segments to remove the low frequency portion of each measurement;

transforming the twelve amplitude measurements taken for the repolarization segments into eigenvariables by using singular value decomposition; and

calculating a spectral density from each of the eigenvariables, wherein the spectral density for each of the eigenvariables is used to locate alternans.

14. A method to optimally measure electrocardiographic alternans phenomena indicative of cardiac instability, including the steps of:

A. obtaining electrocardiographic (ECG) signals from twelve leads over a predetermined number of cardiac cycles, each cardiac cycle having a depolarization portion and a repolarization portion that may exhibit alternans;

B. reducing the twelve lead ECG signals to an orthogonal 3-dimensional eigenlead set, each of the eigenleads representing a plurality of cardiac cycles;

C. dividing the eigenlead signals into four segments for each of the depolarization and repolarization portions;

D. measuring the amplitude in the four segments in each of the three eigenleads for both the depolarization and repolarization portions;

E. arranging the twelve amplitude measurements into twelve independent linear combinations (termed eigenvariables) by rank ordering of mean-square signal amplitudes contained in each of the eigenvariables;

F. separating the spectral energy in the eigenvariables due to alternans from that due to respiration by;

i. determining the eigenvariable with the greatest amount of respiratory energy;

ii. establishing a reference harmonic ratio between the energy due to respiration and the energy due to alternans in the eigenvariable with the greatest amount

of respiratory energy; and

iii. selecting eigenvariables having significant amounts of alternans spectral energy, those eigenleads having respiratory energy-alternans energy ratios bearing a predetermined relationship to the reference harmonic ratio;

G. determining in the selected eigenvariables, the measured power at an alternans frequency and the mean power over a selected portion of the frequency spectrum;

H. determining the difference between the measured power at the alternans frequency and the mean power; and

I. establishing that alternans indicative of cardiac instabilities exists in the electrocardiographic signals when the measured power-mean power difference exceeds a predetermined number of standard deviations.

15. The method of claim 14 wherein the repolarization portion of each eigenlead heart beat signals is divided into segments that extend beyond the end of the visible T-wave in the electrocardiographic signal.

16. The method of claim 14 wherein the determination of the eigenvariable having the greatest amount of respiratory energy is made on the basis of QRS phenomena.

17. The method of claim 14 wherein eigenvariables having a harmonic ratio greater than 1.5 times the reference harmonic ratio are selected as having significant amounts of alternans energy.

18. The method of claim 14 wherein step I establishes that alternans exist when the number of standard deviations exceeds three.

19. The method of claim 14 further including the step of establishing an alternans score using the eigenvariable exhibiting the greatest number of standard deviations.

20. The method of claim 14 further defined as measuring respiration frequencies.